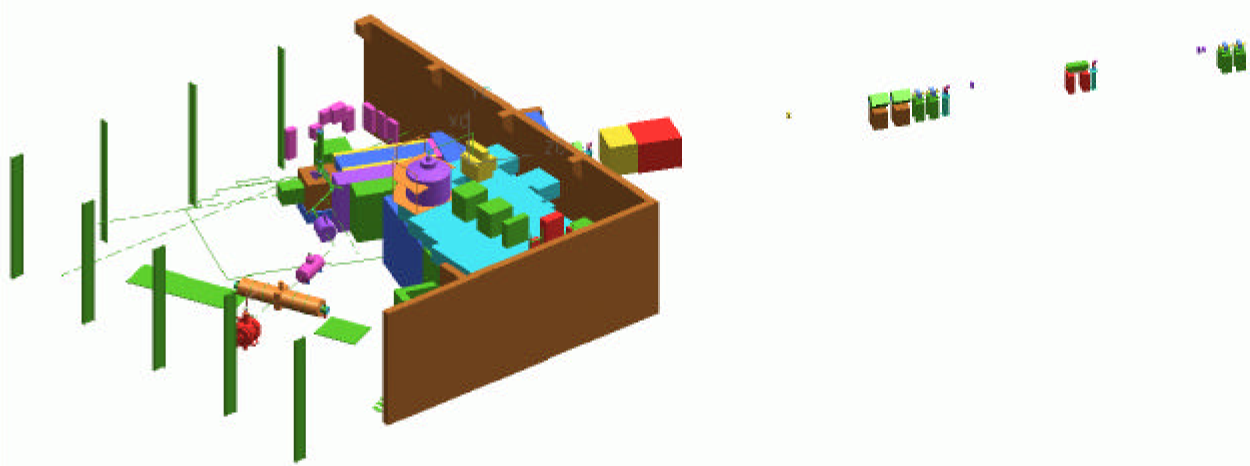
UCN Production for A Experiment at LANSCE

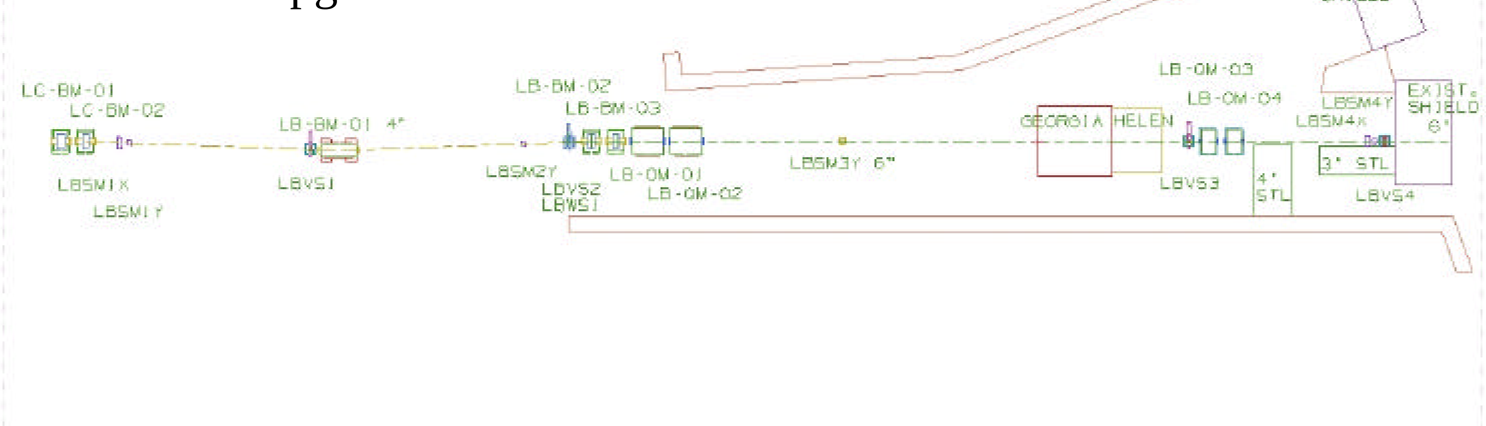
Alexander Saunders (LANL)

- Beam line and accelerator issues
- New shield package for Area B
- Neutron reflectors
- Cooling and gas systems
- Cryogenic solid deuterium source
- Outstanding issues



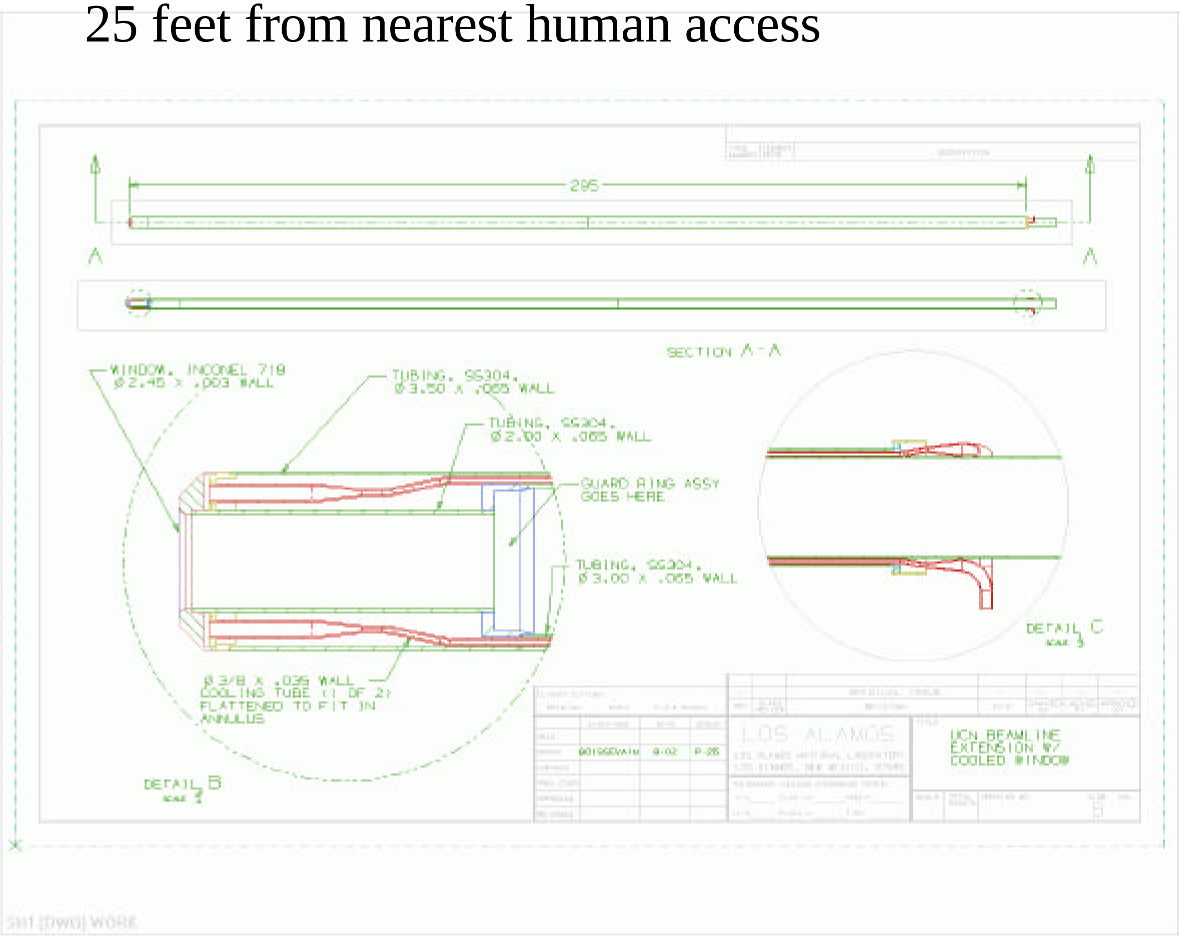
LANSCE and the UCN Beam line

- Requirements
  - 4 microamp average current
  - 40 microCoulombs delivered in less than 1 s every 10 s
  - 90% of protons hit tungsten spallation target
  - No high radiation areas outside of existing PACS system
  - Very low background levels on experiment floor
- Implications
  - Fast kicker required
  - New beam line and shield package in Area B
  - Improved fast-protect system needed
  - Future upgrade: wall between Lines B and C



Beam Pipe Extension and Guard Ring

Aligns beam line to tungsten target and UCN source
Cooling for beam pipe window
Provides last diagnostic for beam tuning/monitoring
25 feet from nearest human access



Status:
Approved
Fab complete
Assembly underway

Goals and Status for UCN Beamline

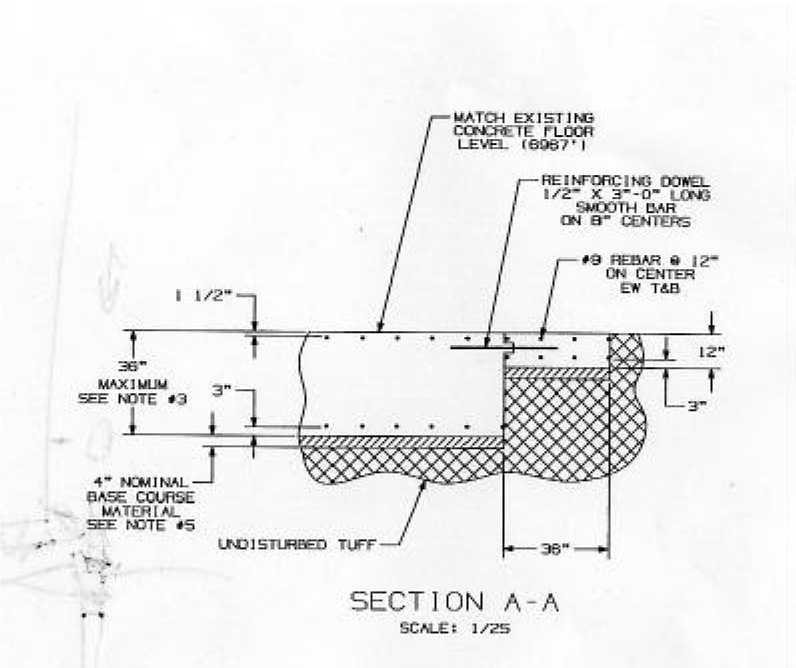
- Goals
  - Complete beam line, with full capabilities, to come on in 6/03
  - Minimal test beam line for 1/03; allows single pulse operation
    - No quads?
    - Benders, TV camera diagnostics
- Status
  - Beam line construction in progress
  - Magnets in place
  - Minimal control and run permit system to be installed by 1/20/3
  - Full control, diagnostic, and safety systems to be installed spring 03
  - Schedule developed by Baldwin
  - Contacts:
    - P-25: Merrill
    - LANSCE-6: McCrady
    - ???

Area B Preparation

Internal lab funding provided for removal of legacy equipment

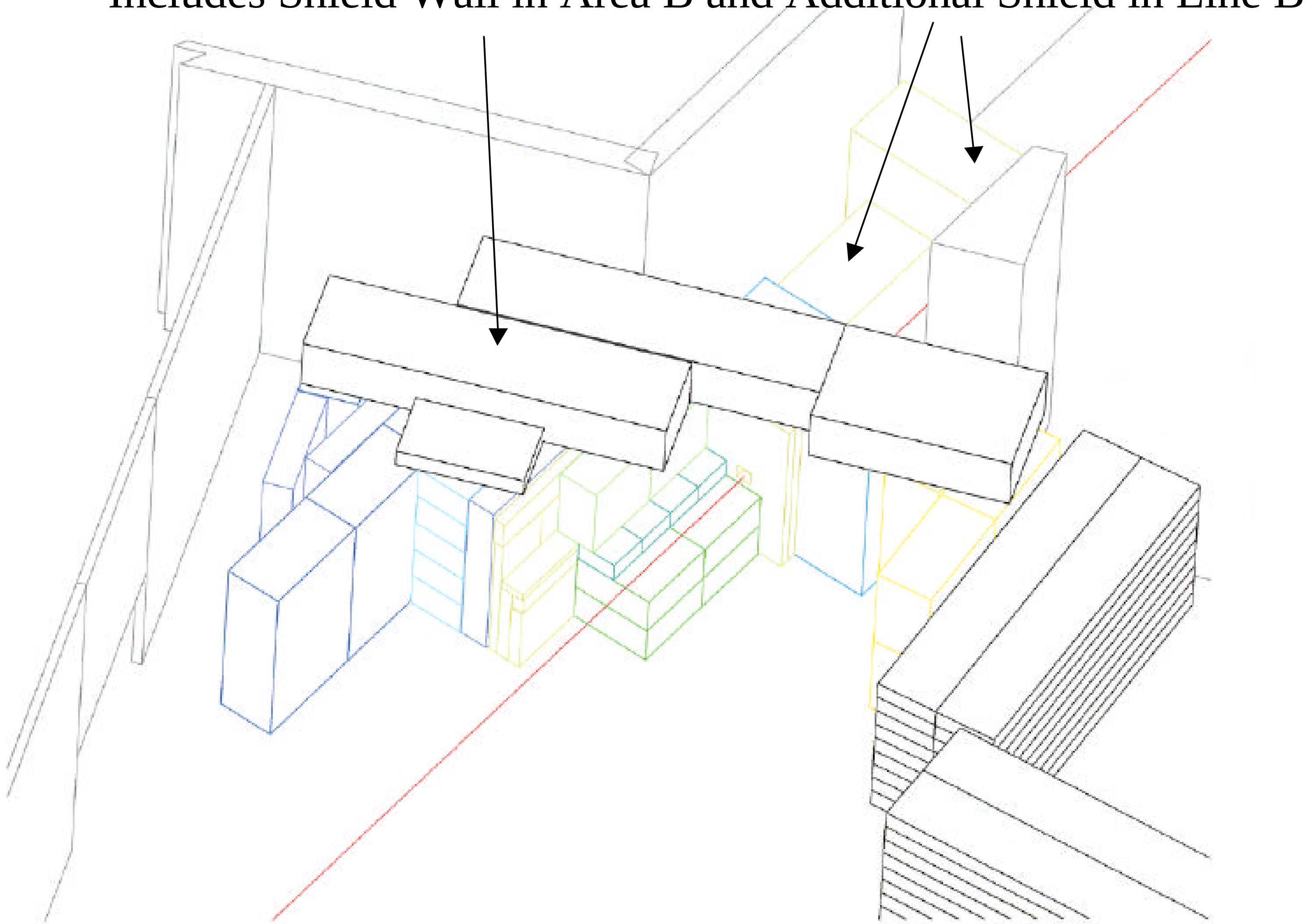
Area B Floor Replacement

•800 lb/sf maximum on original floor; insufficient for shield package
•New floor allows 7500 lb/sf; engineer-approved
•Floor construction complete



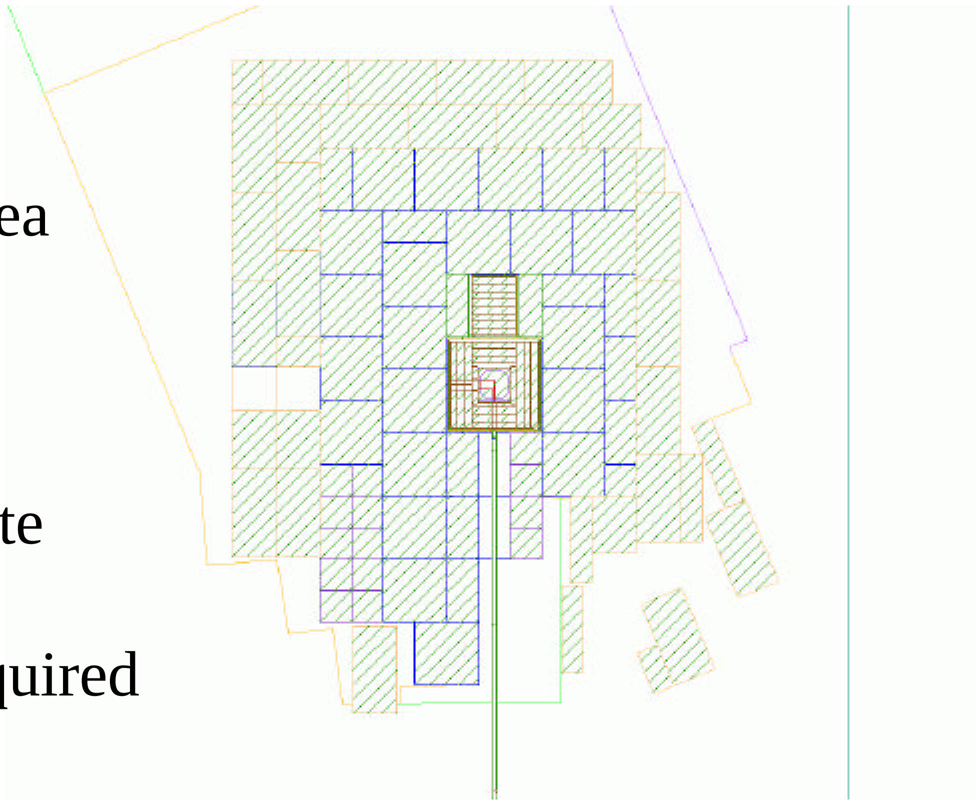
Phase 1 Shielding Allows PRAD to Run in Area C

Includes Shield Wall in Area B and Additional Shield in Line B

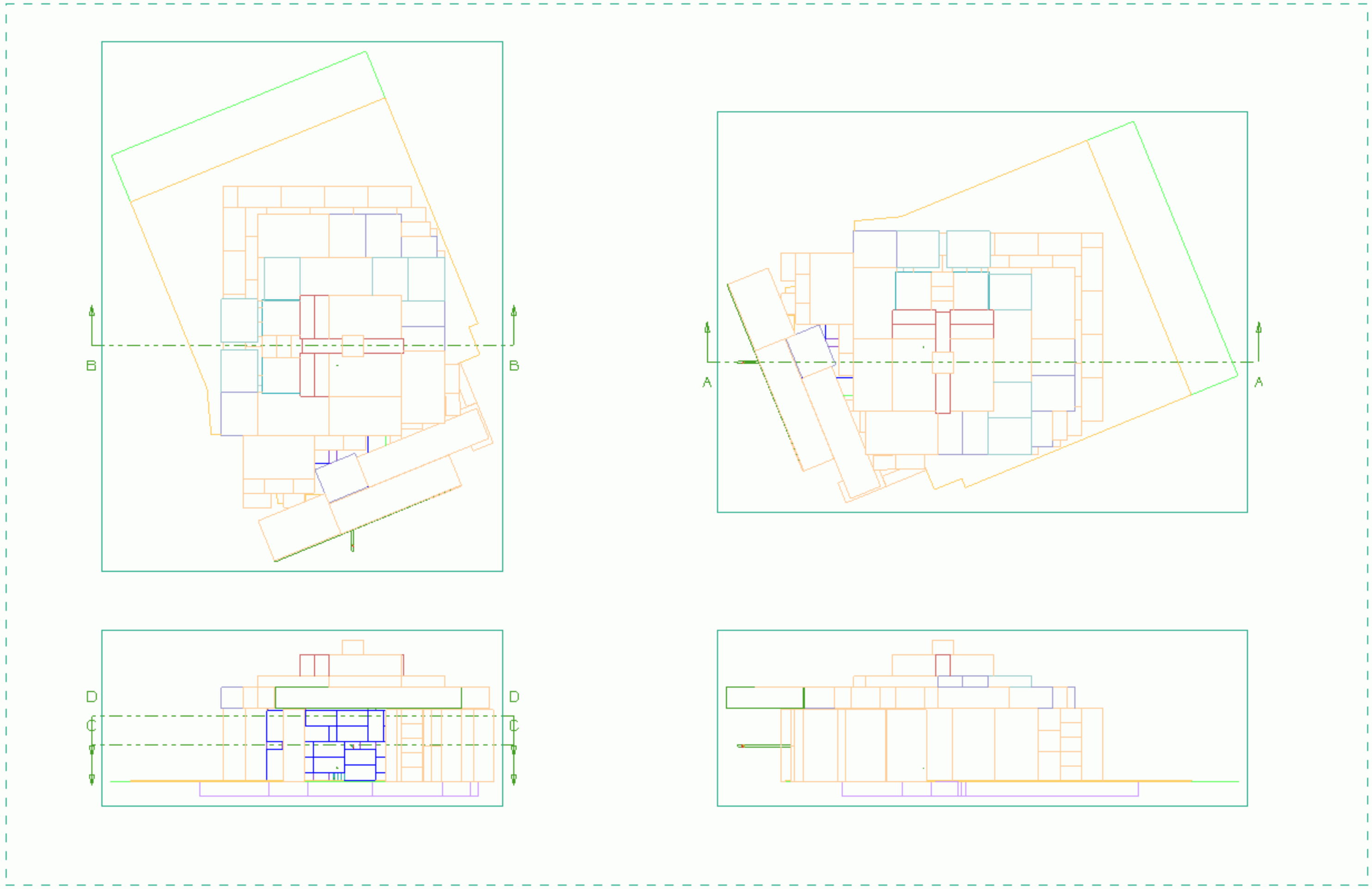


Shield Package for Area B

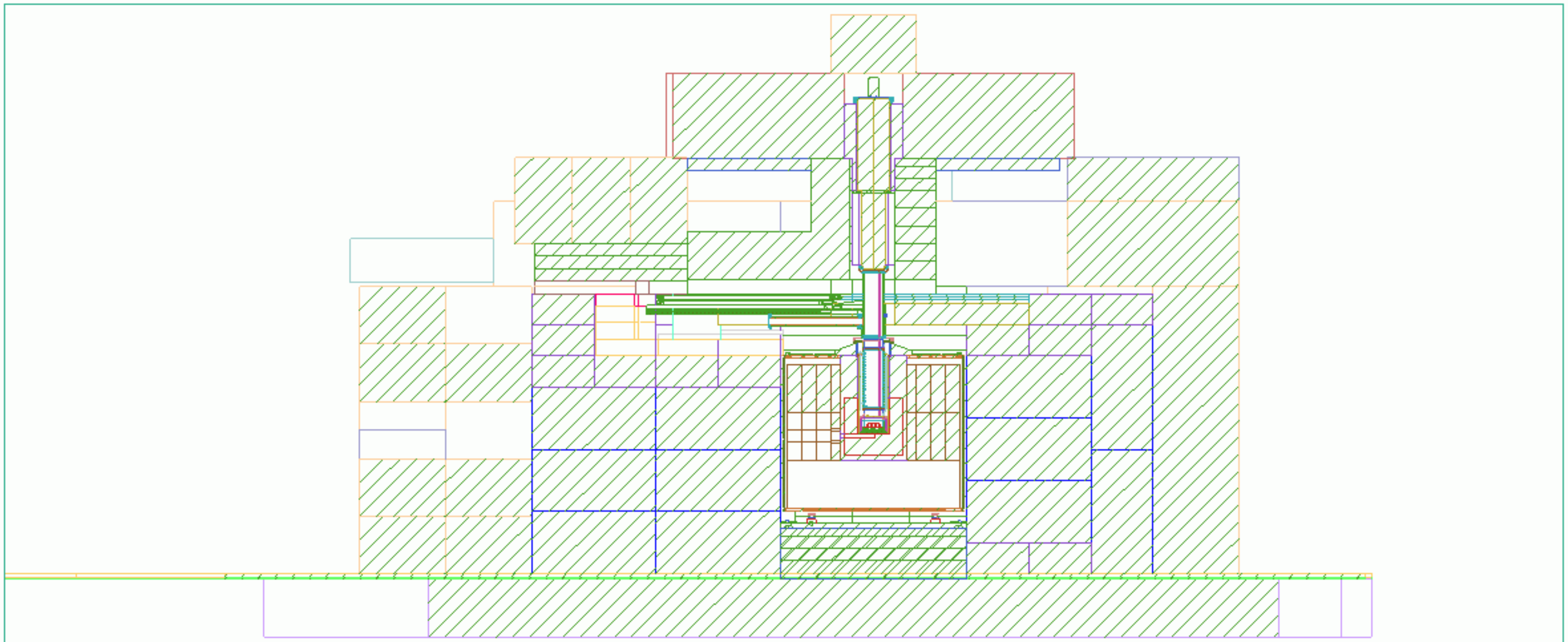
Requirements:
No high radiation areas
Very low backgrounds
Goals at 10 microAmps:
<< 5 mr on floor of Area B
< 5 mr in NTOF and access area
< 100 mr on roof



Implications:
9 feet of steel, 6 feet of concrete
Thinner roof
Spill detection/ fast protect required
Reinforced floor
Design: Kelsey/Mortensen



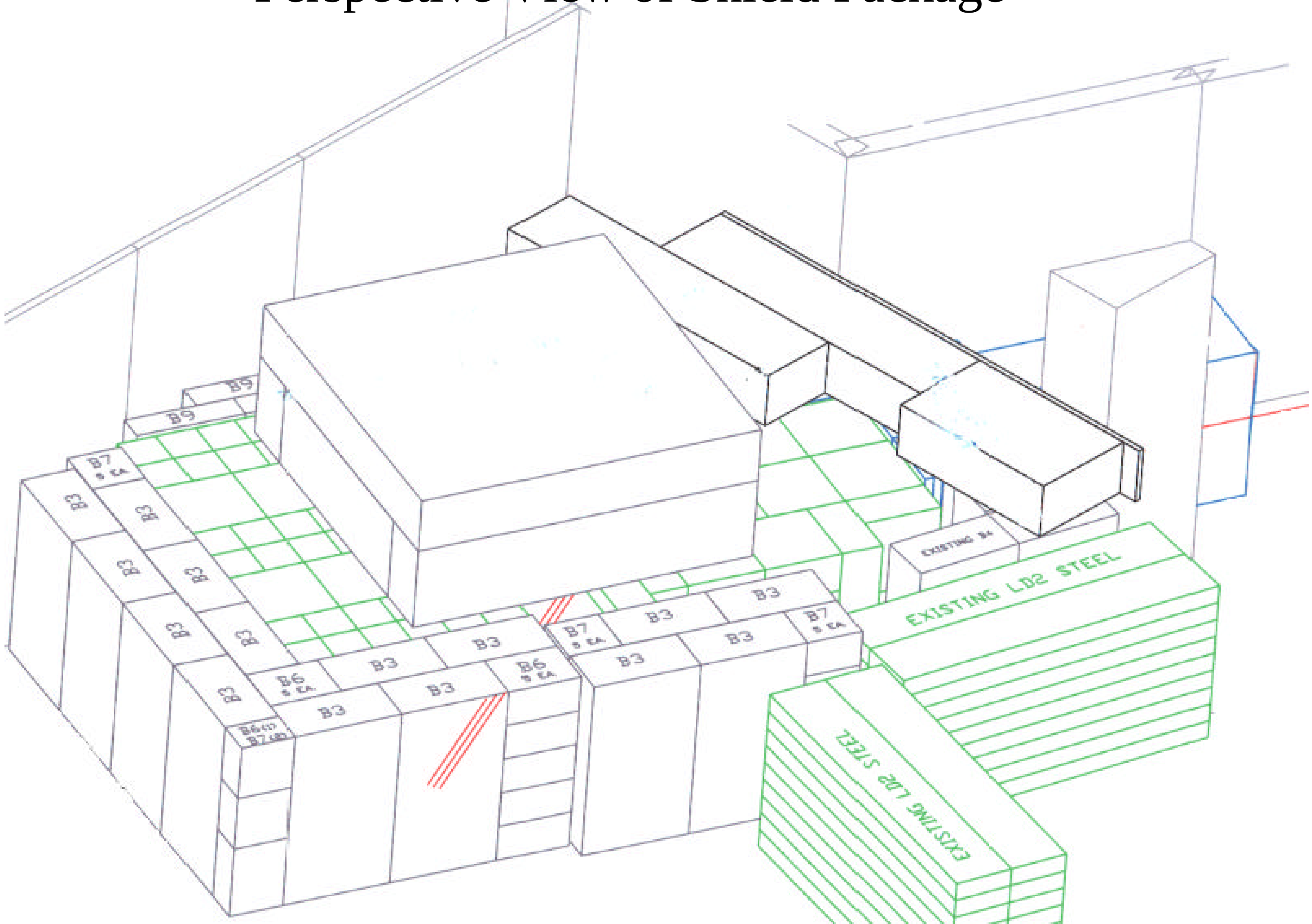
SH3 (DWG) WORK



SECTION B - B

SH5 (DWG) WORK

Perspective View of Shield Package



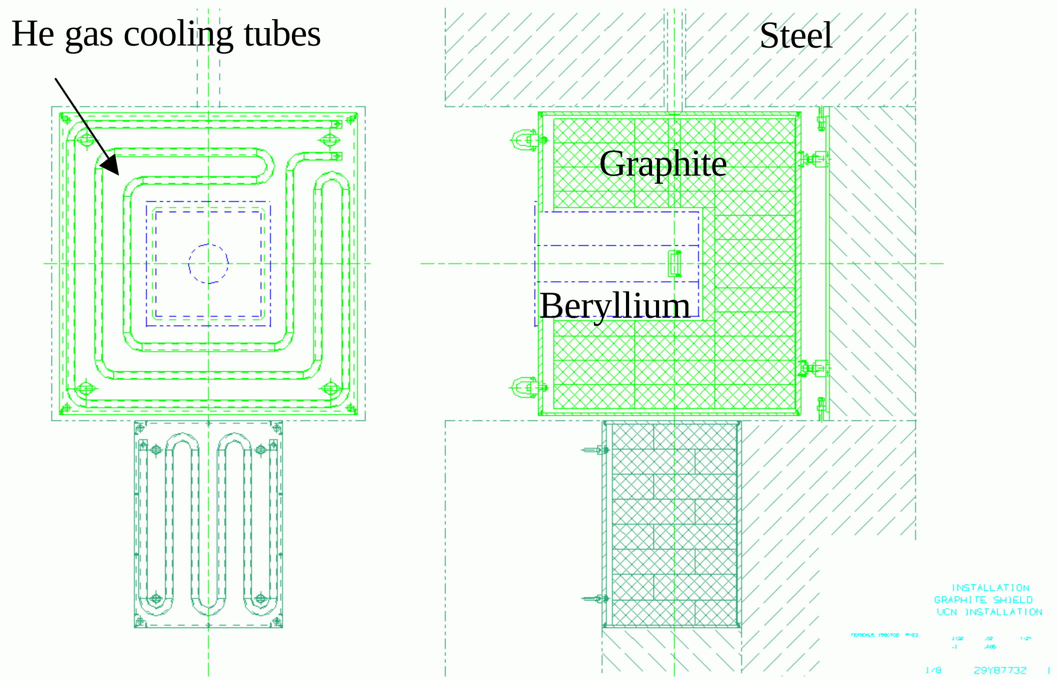
Goals and Status of Area B Shield Package

- Full shield package to be installed by 1/03
- Allows testing of background levels on floor using single pulse beam
- Approval for single pulse beam by 1/03
  - Radiation Safety Committee input
  - USID: Ron Selvage by 12/20
  - DoE or Division approval needed by 1/20/2003
  - Experiment, not facility
- Approval for high current running by 6/03
  - Radiation Safety Committee input
  - "Facility" approval process; USI
  - Approval process during spring
- Status
  - Bulk package designed and RSC approved
  - Ports designed; design approved (UCN port, utilities port, cryo insert)
  - Stacking in progress
  - Initial block-by-block stacking plan in place

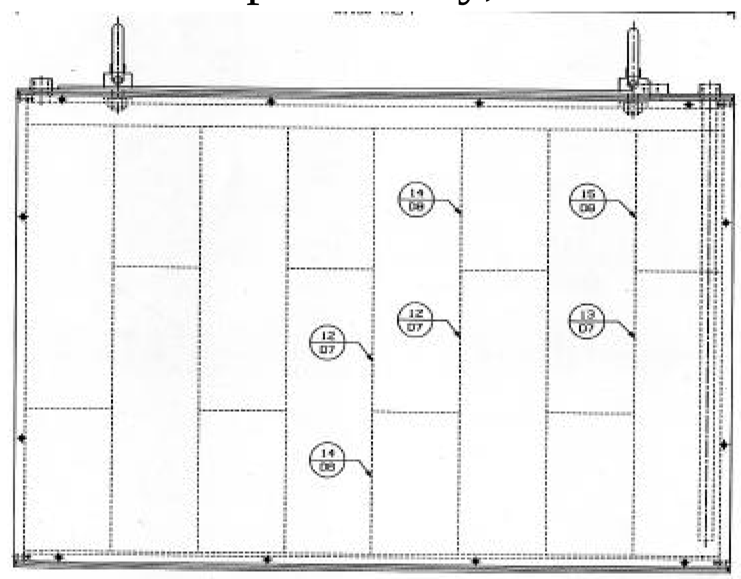
Graphite Moderator Box and Beam Stop

This Graphite and Beryllium assembly:

- Reflects and amplifies the spallation neutrons
- Aligns the cryogenic source, beam line, and tungsten target
- Serves as secondary containment for cooling fluids and d2
- Contains radioactive gas emissions
- Is helium gas cooled via channels in the top plate



Beamstop assembly, side view



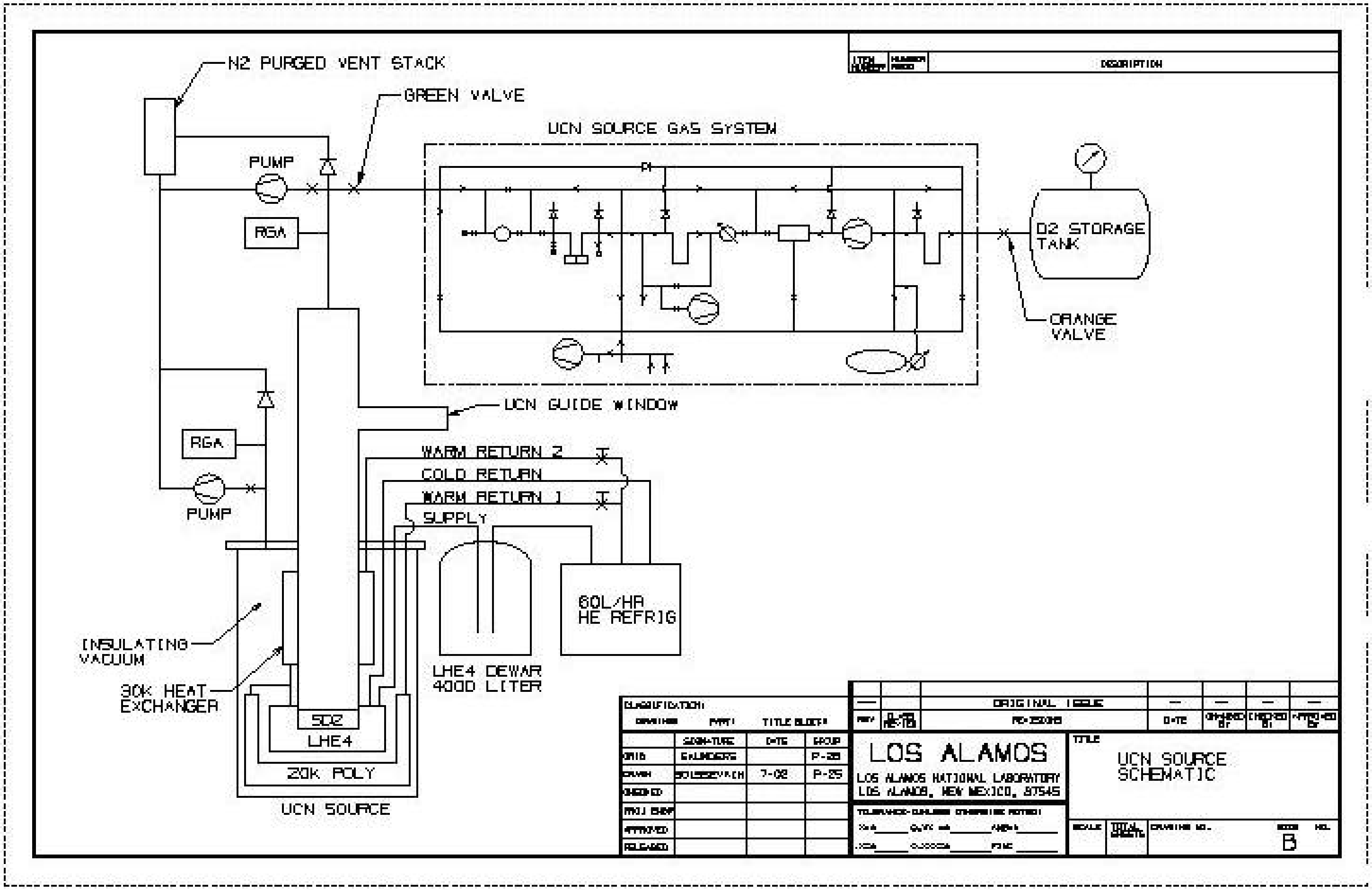
Steel shell around Graphite

Beamstop/moderator box status and goals

- Goals
  - Beamstop complete for 1/03 run
  - Good approximation of moderator available for 1/03
  - Complete system in place for 6/03 run
- Status
  - Beamstop complete, ready for installation
  - Graphite moderator box in shops; due here for final assembly 2/6/03
  - Beryllium moderator box design underway (changing rules)
    - Concept: “mostly sealed”, triply contained, separate volume
  - Graphite machining for 1/03 in progress

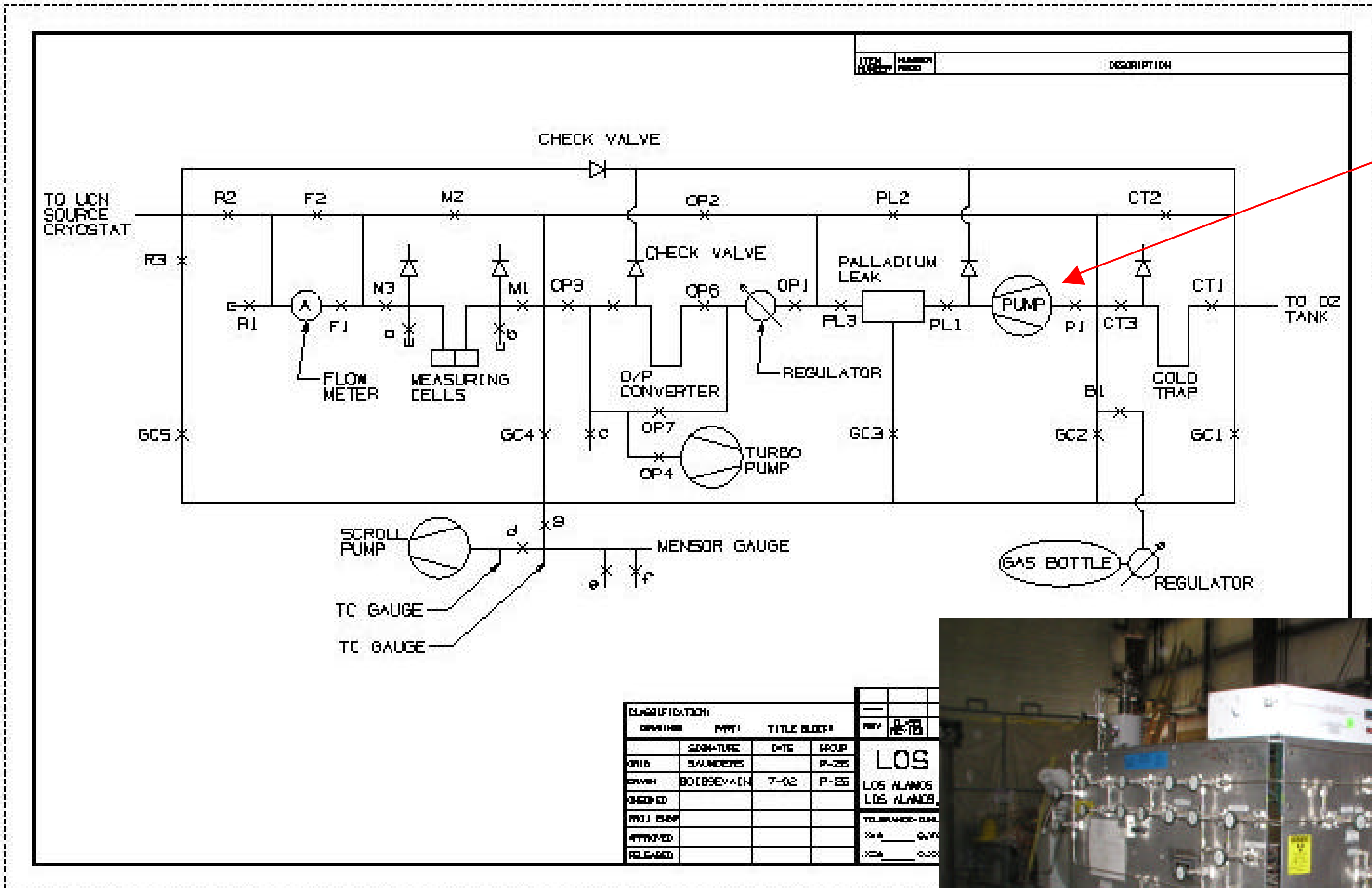
Cryogenic and Gas Handling Facilities

Cryo system needed for high current running, 6/03



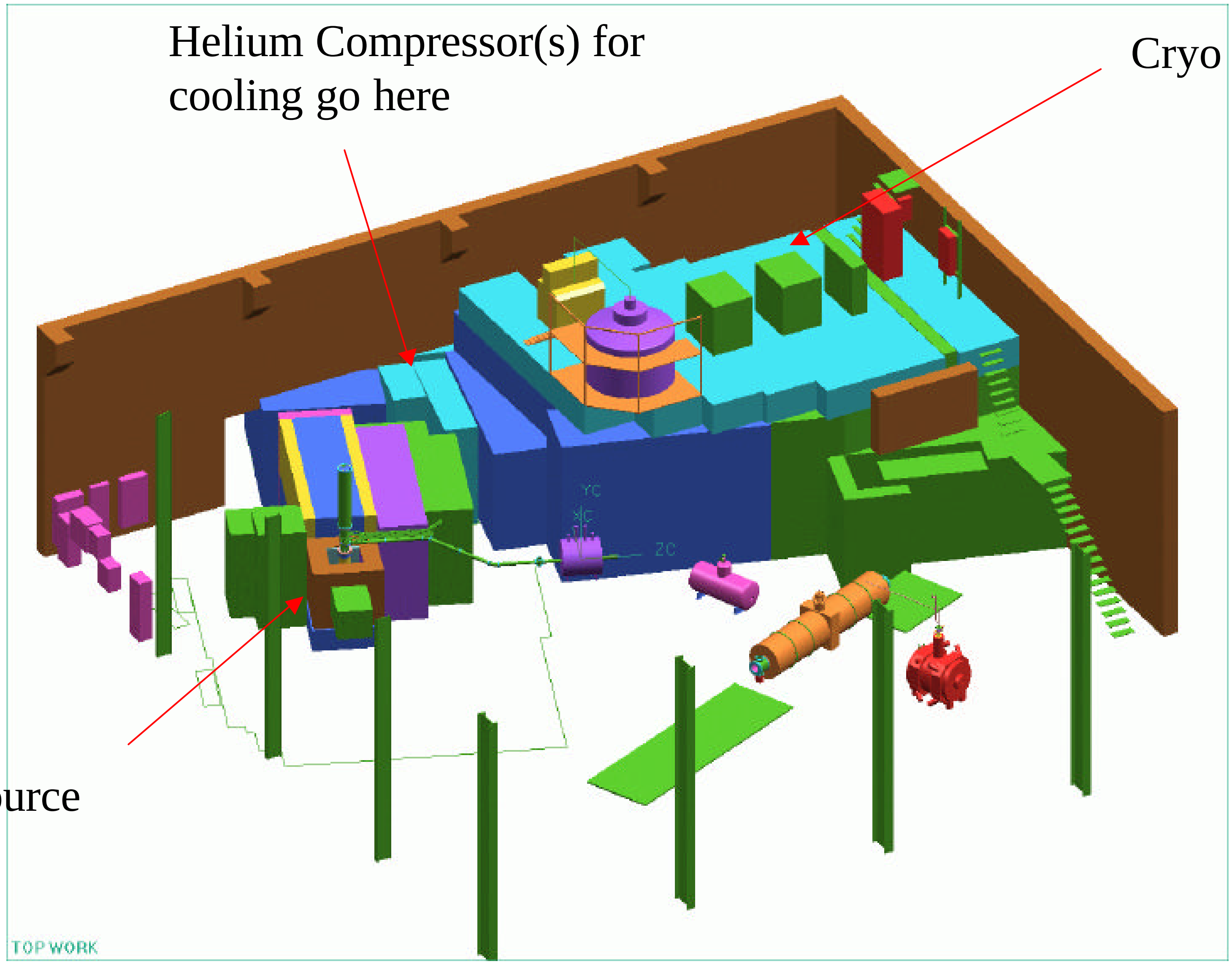
Deuterium Gas Handling System

Modifications needed to prototype for full scale source system



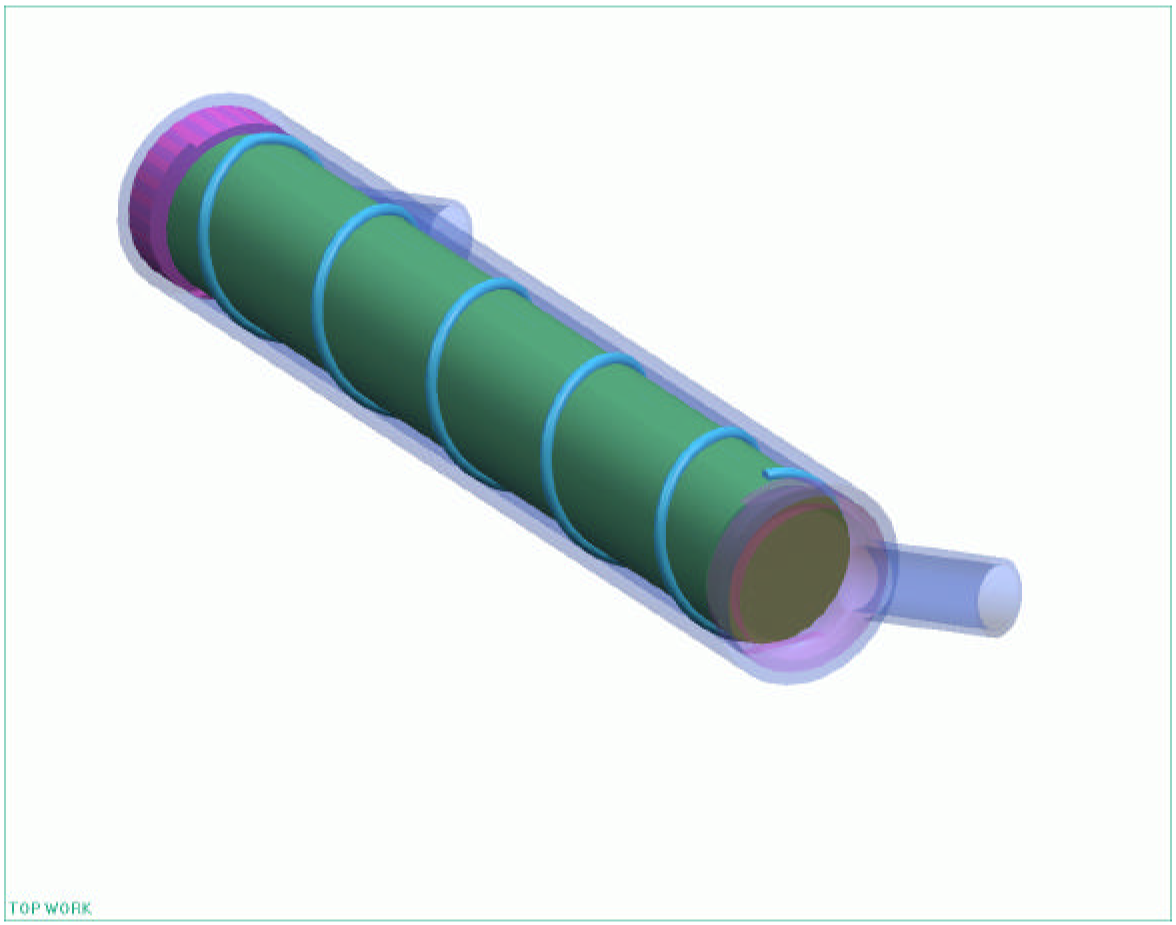
New Pump

Cryo and Gas Systems to be Installed on Existing Mezzanine



Tungsten Spallation Target Cooling

2 cm tungsten cylinder cooled by helium gas flow
Bare cylinder sufficient for 1/03



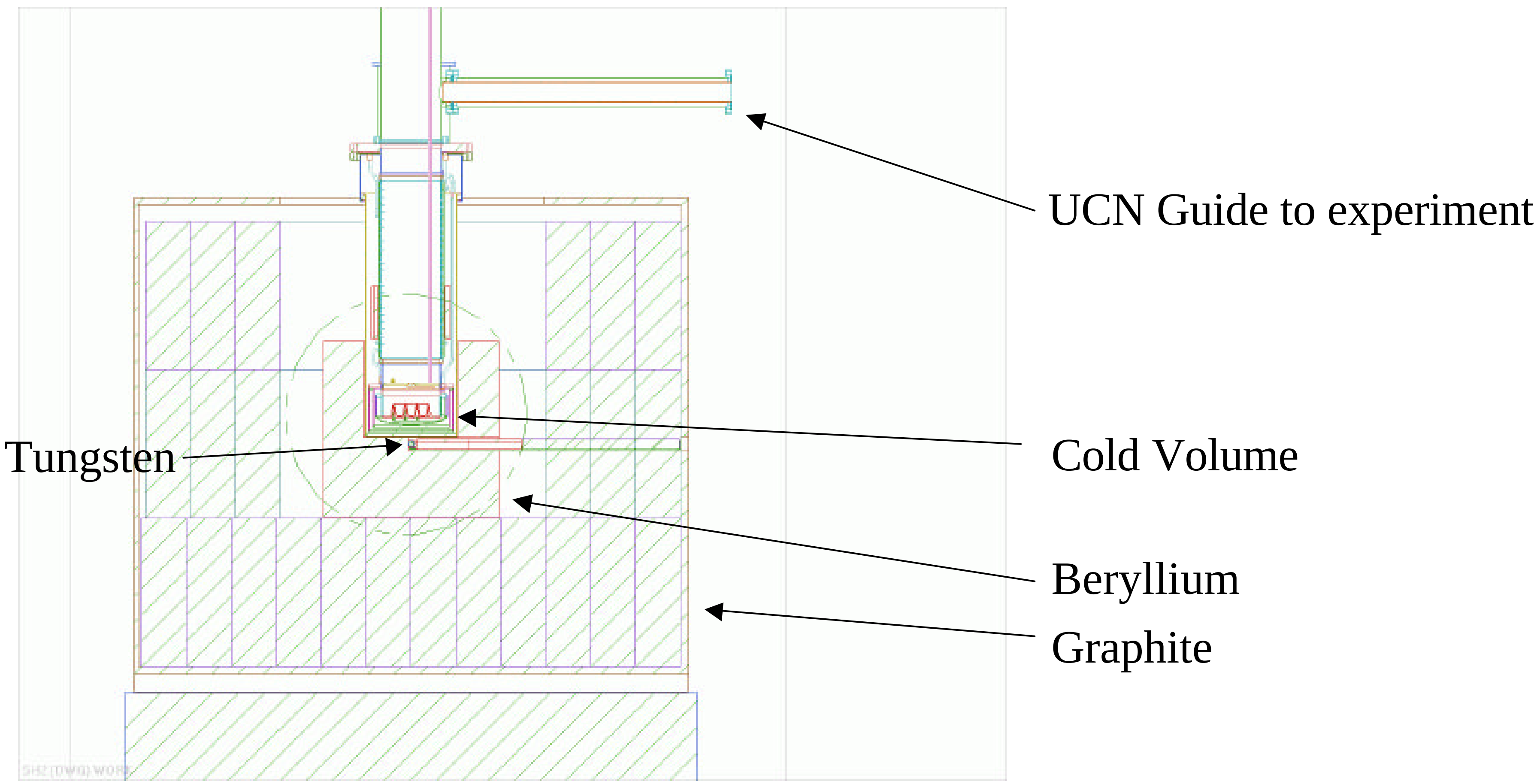
Goals and Status for Cryo and Gas Systems

- No cryogens or deuterium in 1/03
- Full cryo system needed in 6/03
  - Parts identified/overall design complete
  - Refurbishment of liquifier/compressors in progress; complete by 12/20
  - Utilities hookup and installation in spring 03
  - Transfer lines ordered
- Gas handling system exists; upgrades/refurbishment needed
  - New pump defined
  - Ortho/para converter catalyst
  - Increase diameter of return line
  - Larger deuterium storage tanks

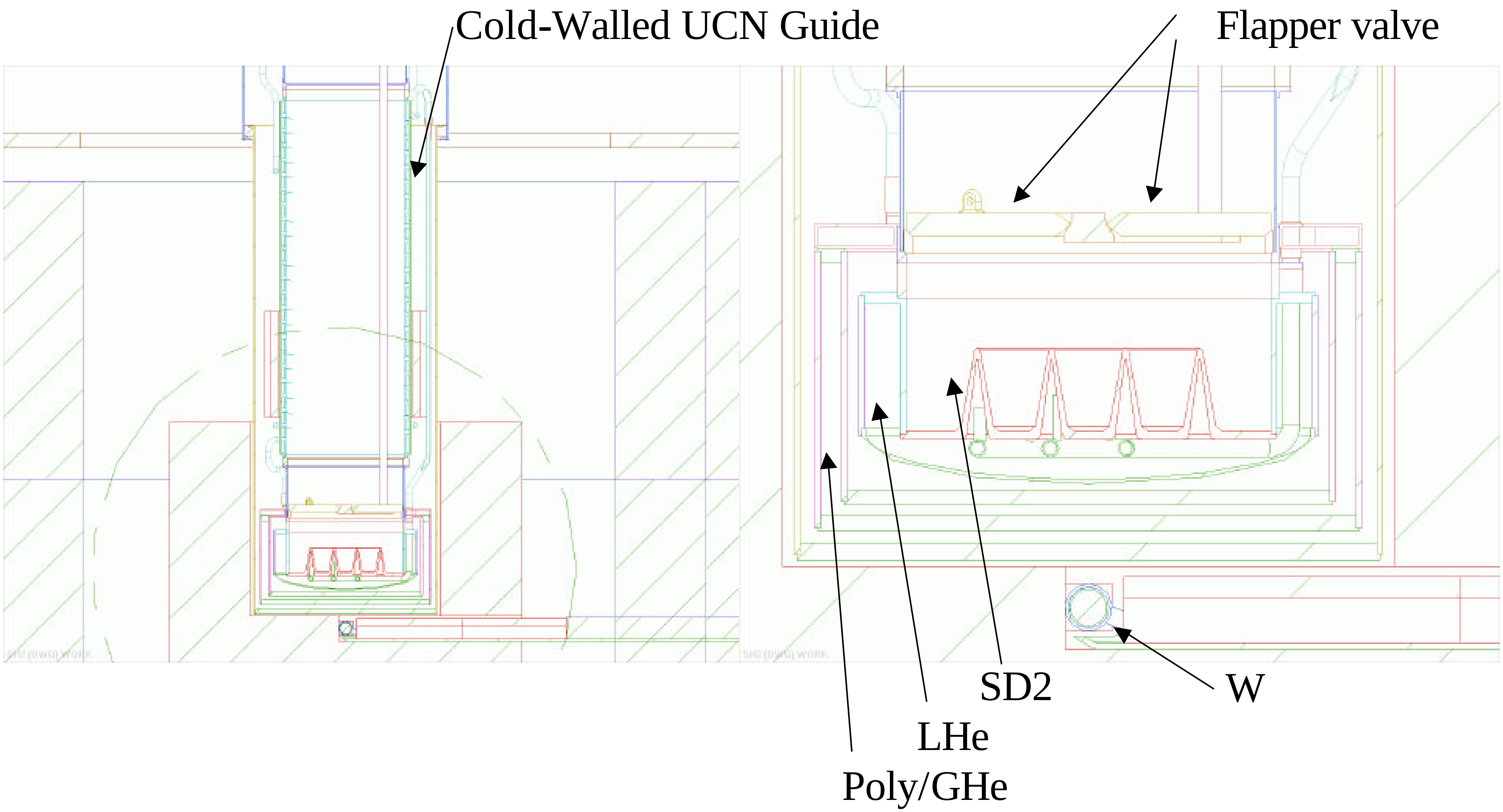
Cryogenic Solid Deuterium Source Insert

- Cryogenic source has three purposes
  - Cool polyethylene cold neutron box to best temperature
  - Cool solid deuterium to lowest possible temperature
  - Conduct UCN away from solid deuterium and to experiment
- Liquid helium cools solid deuterium; boil-off gas cools poly
- Desired schedule:
  - Offline tests winter/spring 03
  - Make any required changes in Spring 03
  - Final testing with protons in 5-6/03
  - Production to experiments in 7/03

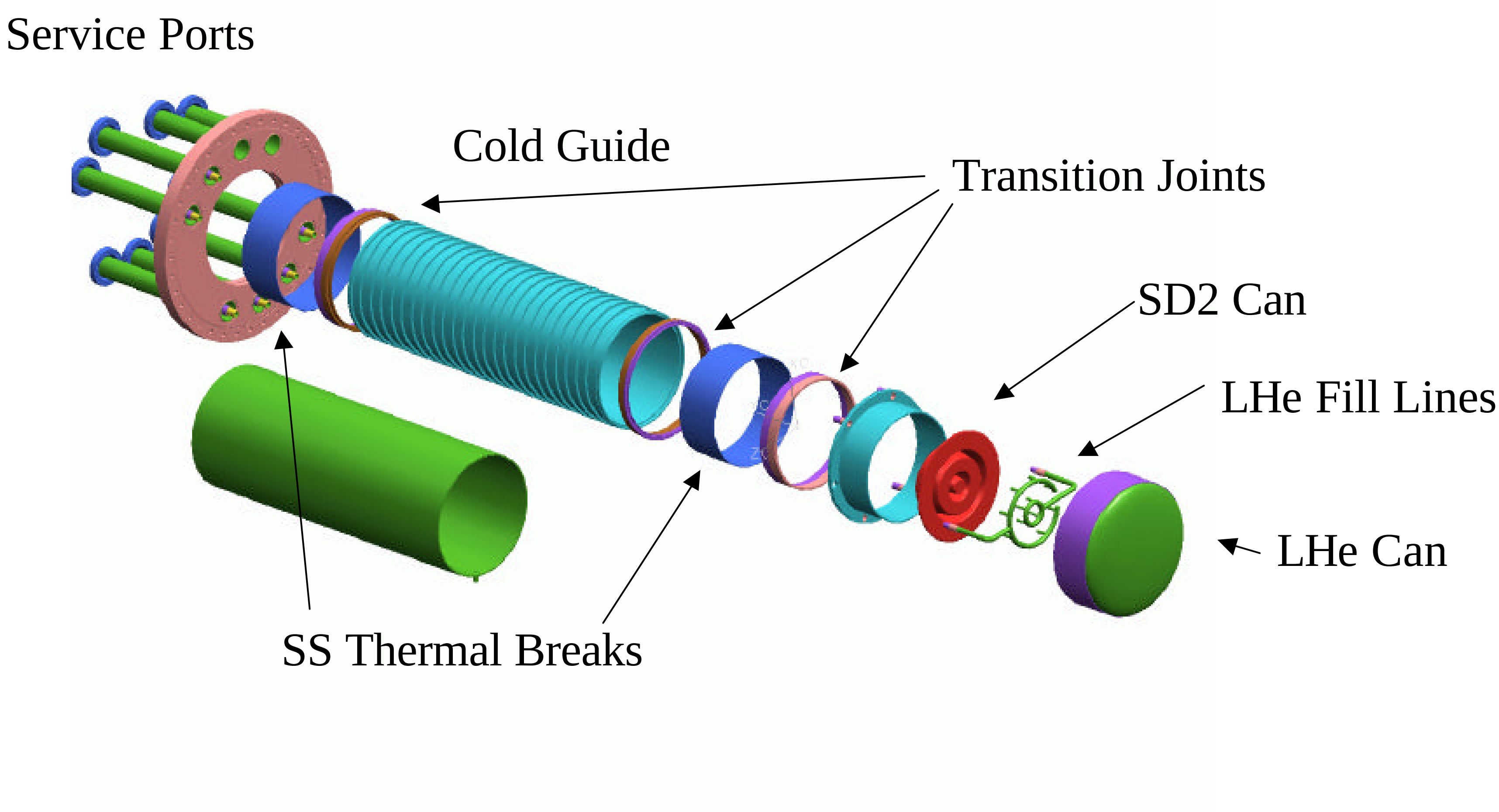
Cross Section of Cryogenic Source Insert



Cold Section of Cryogenic Insert



Exploded View of Cryogenic Insert



Deuterium Flapper Valve

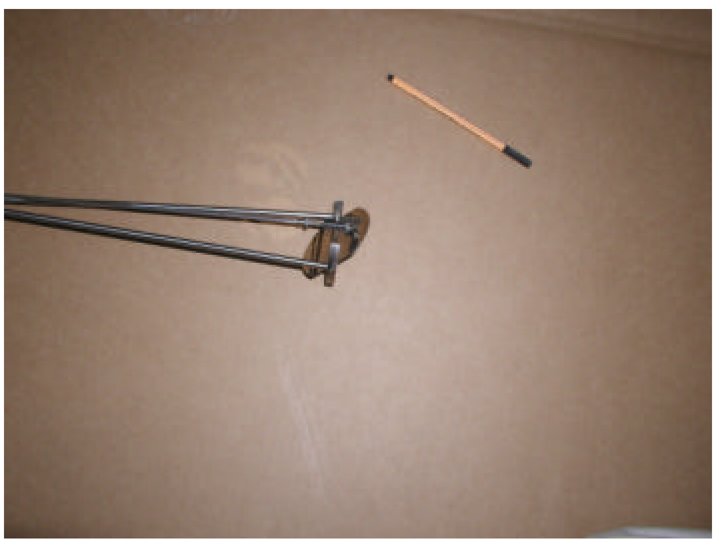
This valve has two purposes:

1) Keep cold neutrons in contact with solid deuterium
2) Keep UCN out of contact with solid deuterium

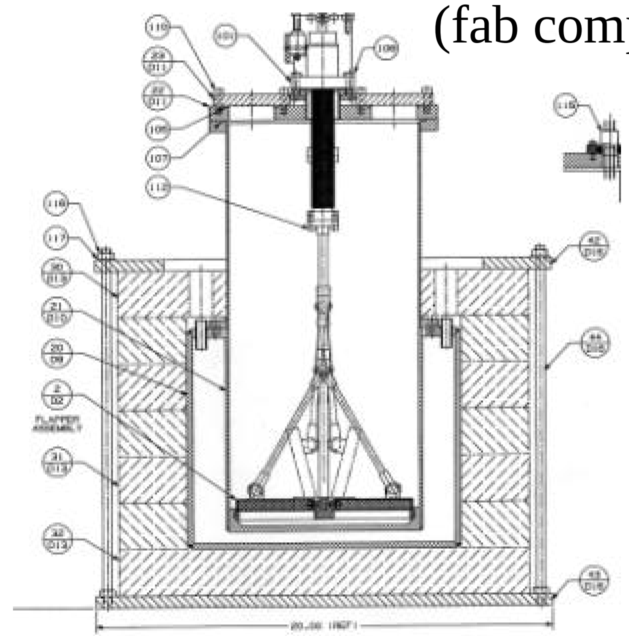
Function:

Closed when proton beam arrives
Quickly open to allow UCN to escape SD2
Quickly close to keep UCN away from SD2

3 inch prototype (w/o cold neutron valve) tested in 2001



Test Setup
(fab complete)

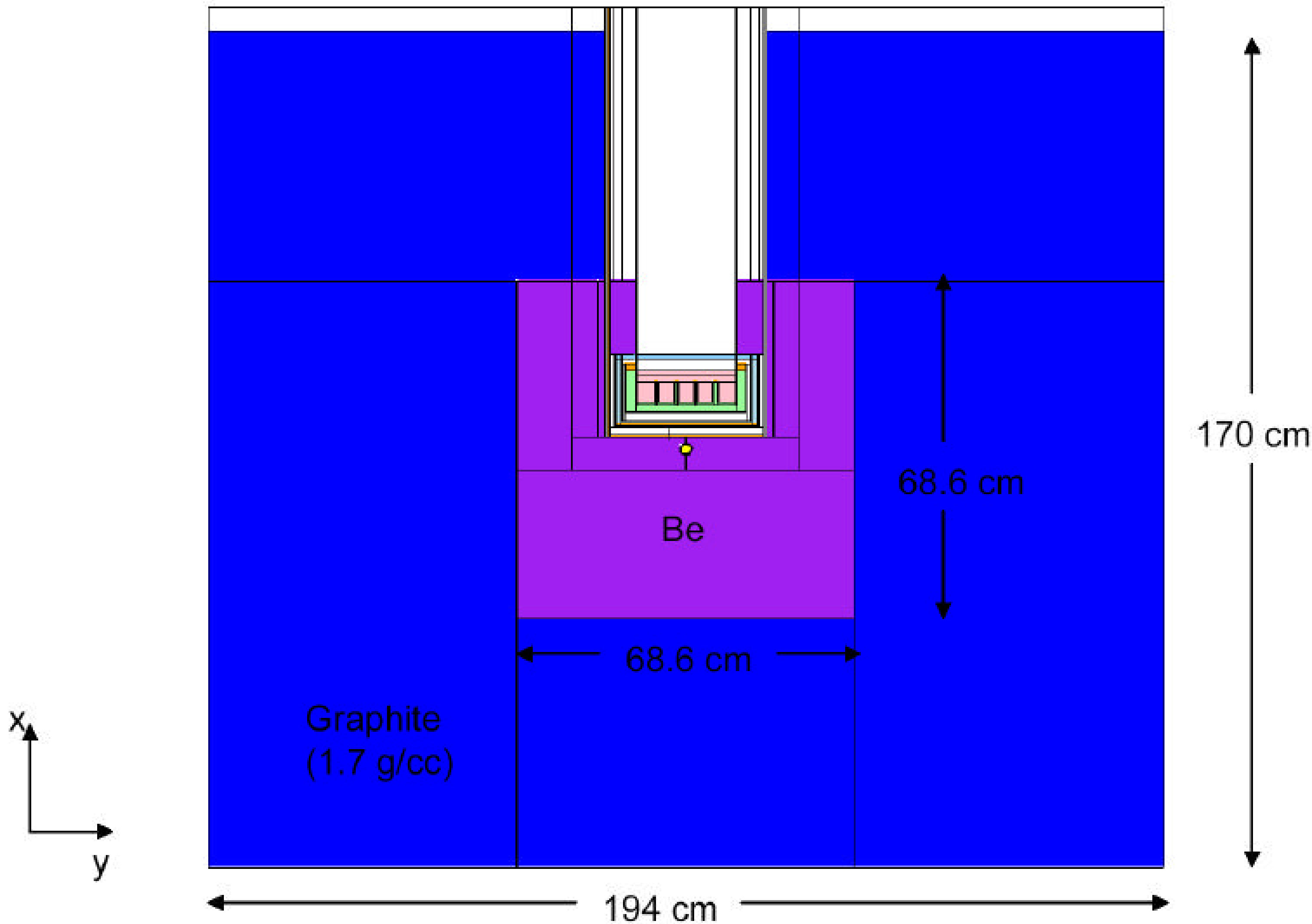


Status and Goals of Cryogenic Insert

Many parts; long lead items in shops
Delivery winter/spring 03
Can be rebuilt if necessary in Spring 03
Final testing with beam in 5-6/03
Parts have started to arrive from shop; assembly and coating

Notes:
Coating for UCN friendliness
Transition joints for thermal performance
Multiple inserts for easy replacement of vulnerable parts

Monte Carlo Predictions of Source Performance



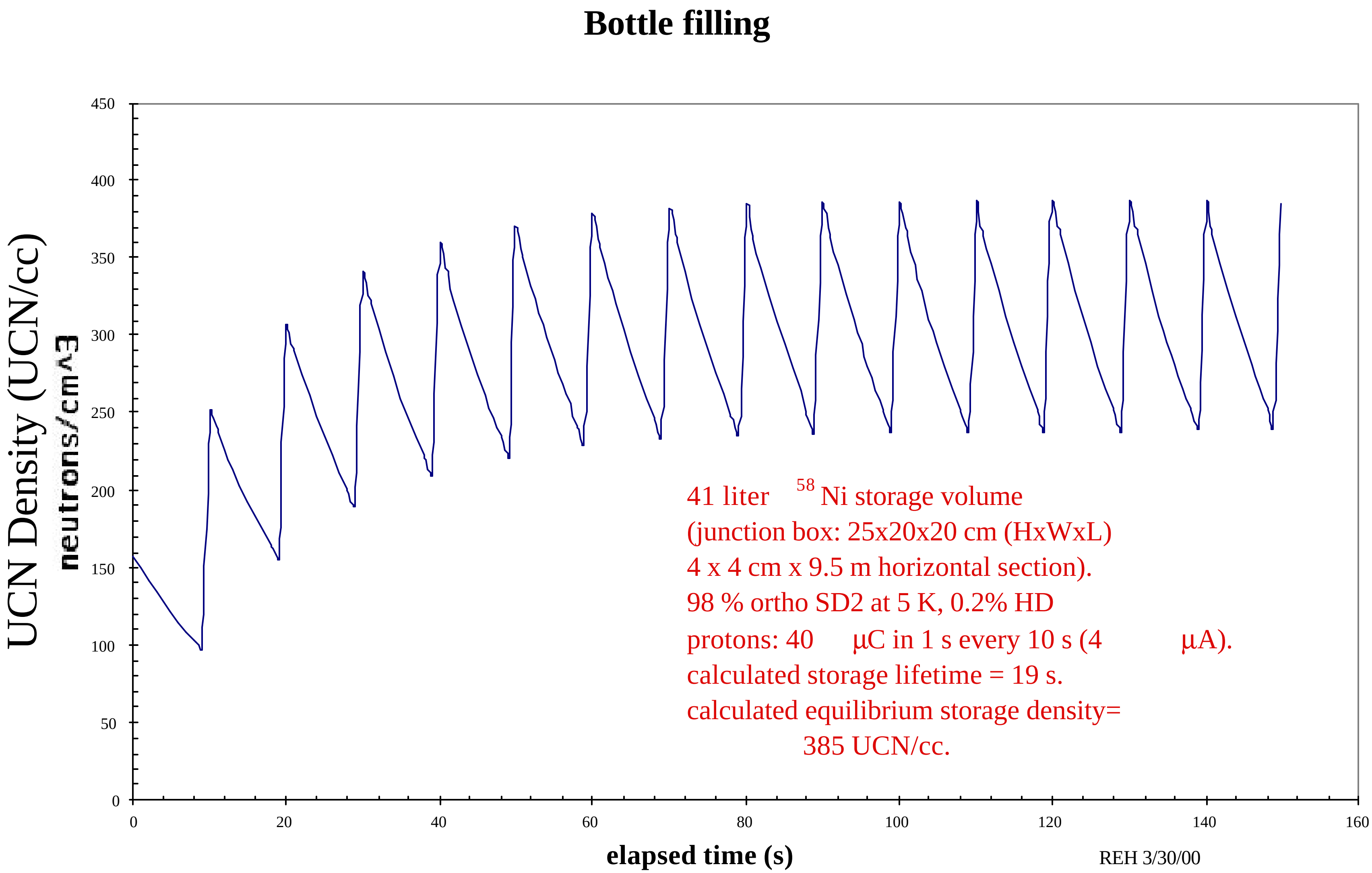
Monte Carlo Predictions of Heating

Problem AB172		Thin Al bottom plates		6.7 cm SD2, Vol=1917 cc		UCN = 1068 UCN/cc/µC	
Assembly	Component	Protons	Pions	Neutrons	Gammas	Sub-total	Total (W/µA)
Target	W	236.325	3.444	0.399	4.595	244.763	
	Inconel can	11.521	0.297	0.153	0.256	12.226	
							256.989
Be reflector		121.290	4.652	38.813	22.642		187.398
Vac Shield	Al disc	1.483	0.094	0.114	0.195	1.886	
(6061 Al)	Al cylinder	0.577	0.037	0.073	0.466	1.154	
							3.040
CH2 Moderator	CH2 bottom	0.642	0.052	0.898	0.111	1.704	
	CH2 sides	0.534	0.039	0.849	0.272	1.694	
	Al jacket	1.976	0.151	0.204	0.782	3.113	
	CH2 cap	0.015	0.002	0.040	0.018	0.075	
							6.585
LHe reservoir	He bottom	0.051	0.005	0.088	0.012	0.155	
	He sides	0.051	0.007	0.094	0.023	0.174	
	Al sides	0.209	0.019	0.028	0.160	0.417	
	Al cap	0.056	0.005	0.009	0.085	0.155	
	Al Bottom	0.290	0.025	0.033	0.091	0.439	
	Al fins/plate	0.435	0.045	0.076	0.208	0.765	
							2.105
Guide tube	Al 4K	0.149	0.014	0.020	0.117	0.301	
	SS section	0.068	0.008	0.005	0.193	0.274	
							0.575
SD2		0.221	0.020	0.984	0.081		1.307
Total 4 K							3.713

21 liters LHe boil-off per hour at 4 µA

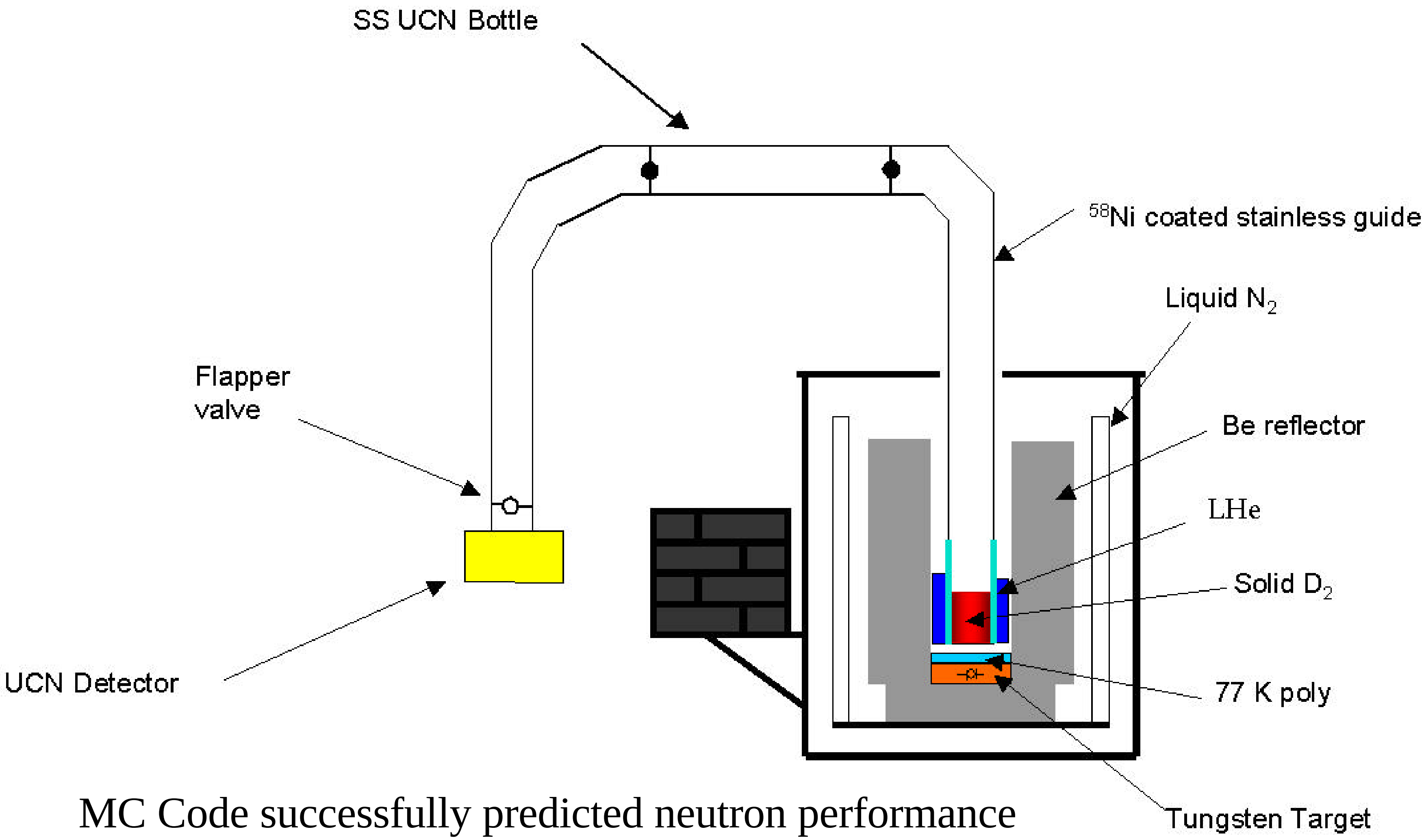
MCNPX also predicts tungsten/beamstop heating rate

UCN Density in Early Flow-Through Bottle



Very Preliminary

Monte Carlo Predictions of Prototype Source Performance

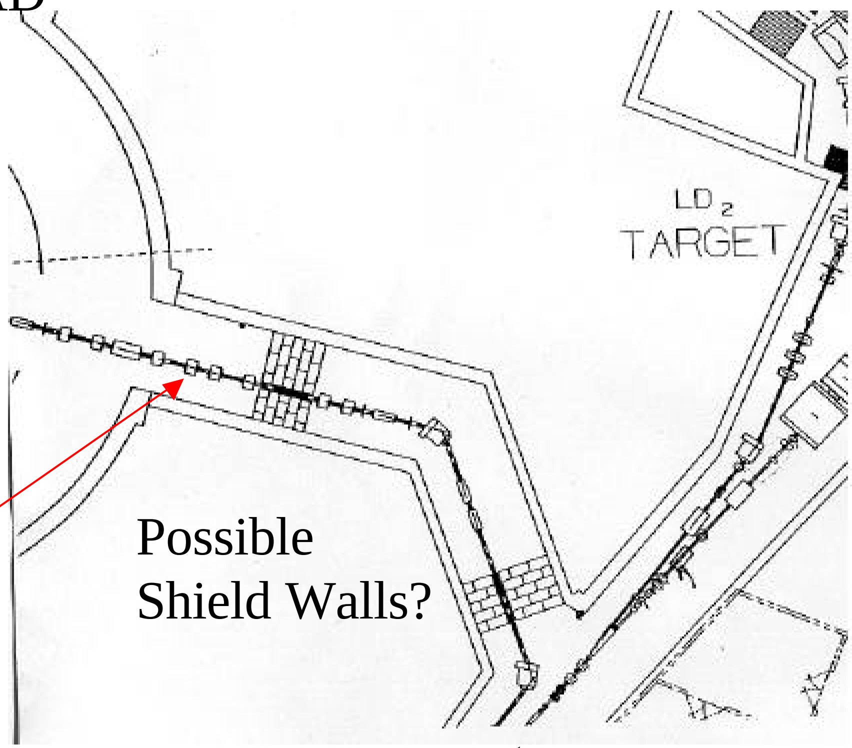


MC Code successfully predicted neutron performance
Heating effects also observed in prototype; consistent with present estimates

Proton Radiography (PRAD) Interaction

- PRAD runs in Line and Area C; UCN in Line B
  - The two lines cannot be run simultaneously
  - Neither beam can be run while Area C is occupied
  - In 2002, PRAD took about 6 12-hour shifts of beam per month
  - In 2002, PRAD required access to Area C during business hours
  - PRAD is the senior user
  - Despite Fast Kicker, PRAD ops will not be at much higher pace in '03
- Possible solutions
  - Shield wall at B/C split (allows Line B to run while Area C is occupied)
    - Technically challenging: shielding, fast protect, PACS, plugs…
    - Additional funding may be required; FY 2004
  - Run in tandem with PRAD in 2003
    - Requires sacrificing 20*12 hours=240 hours of beam per 4 weeks
    - 240 hours is about 1/3 of the beam time

B/C Split Shield Wall



January Run Costs and Benefits

Attempting a test run in 1/03 is a very aggressive tactic:

- Benefits
  - Test shield package
    - Gross gaps found with low beam
    - Background levels on floor tested directly
    - Time to make time-consuming fixes if needed
  - Test beam line
    - How hard is tuning?
    - How good spot size is realistic?
- Costs
  - Some extra work on shield package
  - Beam tune will be imperfect
  - Low level activation of parts in target assembly
  - Time spent on this run is not optimized for the best run in May and June

Summary

- Beam line
- Shield package
- Spallation neutron moderators
- Cryogenic liquid and gas handling systems
- Cryogenic UCN source insert
- Monte Carlo Predictions
- Outstanding Issues